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NASA News Update: **"Space Debris"**

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P R O C E E D I N G S

MODERATOR: Good morning, everyone. Thank you for joining us for this telecon, which is a tutorial on space debris.

As I mentioned to most of you on the phone, this briefing is coming ahead of a 2:00 p.m., Eastern Time, hearing before a subcommittee of Congress on the topic of space debris and how to keep space safe for civil and commercial users. That is why we are embargoing the information from this telecon until 5:00 p.m., Eastern Time. If you are on the line and called on today, you have given me personally your agreement to honor that embargo.

Our briefer today is Nicholas Johnson, who is NASA's Chief Scientist for Space Debris, and with him to help answer questions are Bryan O'Connor, NASA's Chief of Safety and Mission Assurance, and John Lyver, Manager of NASA's Micrometeoroid and Orbital Debris Program.

Nick is going to give you about a 15-minute discussion based on the chart that I have just e-mailed to each of you, who I spoke with yesterday. He will be going through those charts and calling out the pages for you as he goes along.

If you did not receive the chart, please send me an e-mail at beth.dickey-1@nasa.gov, and I will send them out to you individually.

All right. Nick, you are on.

MR. JOHNSON: Thank you, Beth.

As Beth said, we will have a top-level overview of orbital debris -- I think most of you are certainly familiar with the topic already -- and then concentrate specifically on what NASA does to protect its space assets, in particular, from collisions.

As sort of a summary, collision avoidance processes are in place for all of NASA human spaceflight missions and for our maneuverable robotic assets, both in Low Earth Orbit and in Geosynchronous Orbit. These are required by NASA procedural requirements.

DoD provides the screening for us to predict close approaches. They then provide us with information, specifically the miss distance -- and I am certainly associated with that calculation -- and then NASA uses that information along with our own risk assessment process and makes a determination whether or not to maneuver our satellites to avoid a potential collision.

During 2008, four of NASA satellites, including International Space Station, conducted collision avoidance maneuvers, and we also were assistant to France that operates a satellites in an Earth Observations Network to also avoid a potential collision.

If you look at the history of orbital debris population on page 3 of the charts, clearly in 1960 there were very, very few manmade objects in Earth orbit that has continued to grow steadily, almost at a linear rate, up until this year. Clearly, the Chinese ASAT test in 2007 and even the most recent collision in February of this year certainly have been spikes in that overall increase, but the population is such now that we do need to address it and try to do our best to protect the current NASA assets and assist our commercial and international partners and in protecting theirs.

What is orbital debris? On page 4, it is simply, in general, space debris is the supersat. It includes both manmade orbital debris and the natural meteoroid environment. Meteoroids are in orbit about the Sun. The only thing in orbit about the Earth besides orbital debris is the Moon.

Orbital debris is any manmade object in orbit about the Earth which no longer serves a useful function. Typically, this includes non-functional spacecraft, abandoned launch vehicle stages, mission-related debris, debris which is thrown off intentionally, normally during deployment of the mission, and then fragmentation debris. In fact, the majority of debris in Earth orbit has originated from fragmentations, primarily accidental fragmentations.

If you look at Chart 5, it depicts what we call a depiction of the spacial density or you might think of it as the congestion of orbital debris as a function of altitude in Low Earth Orbit, all the way from the lowest altitudes around 200 kilometers up to 2,000 kilometers.

This chart shows the change in the environment since 1994. It indicates the ISS altitude regime which is near the very lowest concentration of debris. It is the less congested area of Low Earth Orbit. The peak is now around 850 kilometers because that was the altitude of the Chinese ASAT test in January of 2007.

If you look at the second peak, it occurred just under 800 kilometers. That was the site of the collision of the two spacecraft in February of this year, and in fact, this is exactly what you would expect. You would expect to see accidental collisions occurring in those regions which have the highest concentration of debris.

Now, this chart has not been updated since the collision. The U.S. Space Surveillance Network is still assessing the amount of debris created. So that peak obviously has grown since this chart was first prepared.

In terms of environment characterization, Chart 6, NASA and DoD cooperated and shared responsibility for categorizing the satellite environment, including orbital debris. The Department of Defense's Space Surveillance Network discreetly tracks objects which are as small as 5 centimeters in Low Earth Orbit and about 1 meter in Geosynchronous Orbit.

Currently, 14,000 objects have been cataloged and are currently in orbit and being tracked by the SSN, and about an additional 5,000 objects are also being tracked but have not yet entered the official catalog.

NASA primarily uses ground-based sensors and inspections to return satellites to statistically determine the extent of a population for objects which are lower than

10 centimeters. So DoD handled the 10-centimeter-and-above population, and NASA tries to characterize the environment below 10 centimeters. We believe that the number of objects larger than 1 centimeter in Low Earth Orbit exceeds 300,000. The combined results then are used for spacecraft and launch vehicle design and operations.

Collision risk. We normally divide collision risk into three categories, dependent upon the size of the object. If the object is 10 centimeters or larger, than it is normally tracked by the U.S. Space Surveillance Network, and we can discreetly determine when a close approach may occur and, if necessary, conduct a collision avoidance maneuver, just simply to get out of the way.

If the object is between 1 and 10 centimeters, this is the worst category because the objects are large enough to cause substantial harm to a vehicle, but they are too small to be tracked and know where their orbits are and where the debris may be.

If it is less than 1 centimeter, then debris shields are an option for most spacecraft. The International Space Station has a large number, over 200 individual shields on its exterior to guard against debris up to 1 centimeter in diameter for most of the vehicle. Again, the greatest risk of space mission comes from the nontrackable debris.

Page 8 simply gives an illustration of the location of the current U.S. Space Surveillance Network sensors. They are a wide range of radars deployed around the world for low-Earth observations, primarily, and for optical telescopes for higher altitude observations.

If you look at the next page, page 9, this is simply an example of vulnerabilities to a spacecraft and particularly the U.S. Space Shuttle. The horizontal axis is in the size of debris, all the way from microns up to meters, and again, we tried to indicate the types of sensors which are characterizing environment force, the large radars on the ground for objects operated by the SSN beyond to about 5 centimeters.

NASA in conjunction with DoD also operates some special sensors and particularly the Haystack Radar and the Haystack Auxiliary Radar which allow us to sense objects down to about 5 millimeters in size, and with this information, we can then determine what the overall population of those small particles are in Low Earth Orbit.

NASA also operates its own radars at JPL's Goldstone facility, and we can see objects as small as 2 to 3 millimeters with that radar.

Overlaid onto this chart then are sample threats or vulnerabilities of the U.S. Space Shuttle to different size debris. At 1 centimeter, for example, substantial damage could be caused to objects in the cargo bay. The actual cabin of the Space Shuttle could be penetrated by objects on the order of about 5 millimeters. TPS tile penetration can occur with just a few-millimeter-size objects.

The RCC, of course, on the nose and the leading edge of the wings is susceptible to 1-millimeter impact strikes, and then as you go down, there are concerns about penetration of the radiators, EVA suits for astronauts on space walks, and we also worry and make a risk assessment concerning the replacement of windows, which we normally wind up replacing one to two permission.

So Chart 10 simply is a summary in a graphical form of what I have just said. The larger debris on the right can be tracked by the U.S. Space Surveillance Network. We can dodge those. The smaller debris, less than about 3 millimeters, are normally not a risk to human spaceflight or robotic spacecraft, and in between, of course, is where the risk really resides.

Going to the next chart, Chart 11, it is sort of the evolution of the NASA collision avoidance process. We have been doing conjunction assessments since 1988, beginning with STS-26. It was a relatively simple technique of trying to prevent objects from coming within a specific volume around the Shuttle.

Before the first element launch of ISS In 1988, NASA and DoD jointly developed and implemented a more sophisticated and a higher fidelity conjunction assessment process for human spaceflight missions. This process is still in place. It continues to be refined and is used to provide conjunction assessments for other U.S. national assets, as well as NASA robotic vehicles.

In 2005, NASA implemented this process for some of our robotic satellites, and in 2007, it became mandatory for all of our maneuverable robotic satellites.

The next several pages, I will go through relatively quickly, so we can have questions. Page 12 simply talks about the basic, that DoD again screens for potential conjunctures, objects which will be coming close to NASA assets.

For human spaceflight, this operation is done every 8 hours at the Joint Space Operations Center at Vandenberg. The JSpOC will then notify NASA of a potential conjunction. The conjunction is assessed. Additional tracking data is acquired. Higher fidelity calculations are then made, and if a risk continues to exist, then a decision will be made whether or not to conduct a collision avoidance maneuver.

Our human spaceflight vehicles have different risk thresholds assigned than do robotic spacecraft. It is sort of a mission-by-mission evaluation of when a satellite needs to be maneuvered. If we decide to do a maneuver, then we obviously inform the JSpOC, so that they can look at our proposed maneuver to ensure that we are not maneuvering into the path of some other piece of debris. So it is an iterative process, until the threat has passed.

The final chart titled "Debris Avoidance Maneuver Planning," within the Human Spaceflight Program, once we detect a risk of collision on the order of 1 in 100,000 or more, we begin to prepare a potential maneuver. If that risk is greater than 1 in 10,000, the flight rules indicate that we will maneuver unless not maneuvering -- unless maneuvering would actually pose a greater hazard -- or not maneuver pose a greater hazard.

Debris avoidance maneuvers are usually small and occur one to a few hours before the time of the conjunction. The Shuttle is much more responsive. We have complete control of that vehicle. For ISS, we have to coordinate with our Russian colleagues in Moscow. So there is a little bit more of a preparation and execution time there.

On average, Shuttle and ISS have conducted several collision avoidance maneuvers over the past 10 years on the order of about one per year, although not normally that often in recent years.

Beth, that is the end of my presentation.

MODERATOR: All right. Thank you.

We will take questions now. Again, you all are muted until it is time to ask a question. Please dial Star/1 to get in the queue for a question. We will do one question and one follow-up per reporter around the circuit, and then we will come back for more if we have time.

We will call on you by name and affiliation, and I would like to let you know that at the end of the call, I will give you information on playback possibilities for this, so that you can listen to it at any time you want for the next couple of weeks.

Our first question is from Bill Harwood of CBS News. Bill?

MEDIA QUESTIONER: Everybody, hello. Thank you very much for taking the call.

Nick, I don't know how to interpret the population in terms of risk. In other words, if the Shuttle is up there at a given altitude, or the Station, for a given period of time, how do you calculate what the odds are that one of those untrackable objects could actually hit you and cause damage?

I mean, in other words, I guess I am trying to get some kind of, you know, feel for what the risk means to manned spacecraft. Is it something that over a period of time, it's bound to happen sooner or later? Is it something that is rare?

And I am not talking about the objects you can track, obviously. I am talking about those ones you talked about in the danger population, the stuff that you can't necessarily track.

I don't know if there's an answer to that question, but that's what I wonder about. Thanks.

MR. JOHNSON: Okay. Let me take a crack at it, Bill.

You know, the good news is that we don't believe that we have lost the operation of any satellite, robotic or human-piloted, due to impact by untracked debris yet. So space is still a big place. Clearly, we operate human spaceflight at altitudes where it is the most benign of anywhere.

What we do is we do have statistical models that basically say that for a given area in that orbit for a given period of time, be it a week or a year, there is probably going to be hit X-number of times by debris of different sizes. So there are a lot more 1-millimeter debris than there are 1-centimeter debris. So, over a period of a year, we can figure out, for example, how many times the International Space Station will probably be hit.

There is also directionality associated with the debris. So certain parts of the Space Station, which is relatively permanently oriented, is going to get hit more often in certain areas, the fore part of the vehicle than it is in the back.

So we do it statistically based on those data which I talked about that we collect from the Haystack, Haystack Auxiliary, and the Goldstone radars.

MEDIA QUESTIONER: Thanks. If I can ask a quick follow-up, Beth?

MODERATOR: Yes.

MEDIA QUESTIONER: Is there a way, Nick, to compare the risk of flying in Low Earth Orbit with manned spacecraft with other things? I mean, I don't really worry about getting hit by lightning. I know it can happen, but I don't really worry about it, or a car wreck, you know, I mean, I know there's a chance I can have a car wreck today, but I don't spend all day worrying about that.

I'm just trying to understand how the risk of flying in space and this environment compares to risk that we all accept in our daily lives.

Thanks.

MR. JOHNSON: Yeah. We've looked at that many times, and it is sort of an apples-and-oranges. It is really hard to make a comparison between that.

You know, there aren't thousands of flights being conducted every day like commercial airliners or millions of automobiles on the road.

So I guess the best way to say it is it is an issue that we are concerned about. Today, we have been able, through design and operations, to really mitigate and to reduce the probability, and I think, although I said it before, we have not had a serious incident due to orbital debris for either Shuttle, the International Space Station, or any of the NASA robotic spacecraft.

So it is not something that you really need to lose sleep over, but it's something that we need to be proactive about and make sure that we do understand what the risks are.

There are risks associated with every spaceflight from a lot of other threats other than orbital debris, and those risks are typically higher.

MEDIA QUESTIONER: Thank you.

MODERATOR: Okay. Rob Coppinger of Flight International Magazine.

MEDIA QUESTIONER: Oh, hi. I would like to know, looking at those pictures where you showed the growth of space debris -- I would like to know do you have any estimation of what point the probability of the ISS being struck one or more times by a large piece of debris, 10 centimeters or so, will get too high.

MR. JOHNSON: We certainly believe that for the anticipated life of the International Space Station that we can maintain the safety guidelines which were established before the -- or at the beginning of the program. Those risks are typically serious impact of no more than about 5 percent over a 15- or 20-year period.

MEDIA QUESTIONER: Okay. And laser ablation, will that be -- is that a serious prospect for resolving the debris issue?

MR. JOHNSON: Are you talking about trying to remove small debris from Low Earth Orbit?

MEDIA QUESTIONER: Yeah.

MR. JOHNSON: You know, that's a concept that we've examined, we examined with DoD back on 1996 under a study called Project Orion.

It is a concept of we are still evaluating some of the technical challenges associated with that, as well as the cost. So it is not something which is going to be able to be implemented in the near term.

MODERATOR: Thanks, Rob.

The next questioner is Seth Borenstein of Associated Press.

MEDIA QUESTIONER: Thank you for doing this.

Nick, last week, we were talking with LeRoy Cain about the actual risk numbers for the STS-125, and, Bryan, please feel free to jump in here. And he said you are now comfortably over that 200 level, but he did say at some point, you were below that. Can you explain how far below you got 200, why -- what happened to get the comfort level, whether that was all done through the mitigation that the Shuttle people do, including jumping down at the last moment, you know, right after Hubble's release, going down to a lower altitude, or did the actual debris -- characterization of debris field change?

MR. O'CONNOR: I don't know all the details that went into that. I know the latest number is okay. We have a threshold of it's okay to quit working on it at about 1 in 200, and we are looking at 1 in 221.

There's a range on that, of course. The worst and best ends of that range at 1 in 167 up to 1 in 302. We have been trying to get our folks to give us these ranges, so we have some idea of the uncertainty that goes with this, and we are using those now to better understand this stuff..

The first time they came out with numbers, it was slightly worse than 1 in 200, and my understanding and characterization of that is they went back and sharpened their pencil. In other words, they used real flight information, not generic. They used this particular flight with its attitudes, its altitude, and those are the basic things that can change a given risk assessment, is changing from one environment to another or pointing the vehicle differently, and when they looked at the day-to-day vehicle attitudes, rather than just a single altitude for the whole mission, the numbers came out better.

So, as far as I understand, the team is happy with that. They don't have to elevate it to a higher level for approval now, which is what happens if you're going to be worse than 1 in 200. It gets out of the program's authority to approve that.

MODERATOR: Everybody, that was Bryan O'Connor speaking.

MEDIA QUESTIONER: And if I could follow up with a quick question for Nick on this. After Hubble is deployed again, the Shuttle goes back down to, you know, a different altitude. I don't remember what it is. How much of a -- how much does the risk number go down? In other words, how much do you gain? It goes from 1 in 221 to what, 1 in 200 or 1 in 400 or 1 in 280? I am just wondering how much do you gain by that quick maneuver.

MR. JOHNSON: Well, actually, we gain a lot, but the 1 in 221 is for the entire mission.

MEDIA QUESTIONER: Okay.

MR. JOHNSON: So I can't tell you what offhand. I don't remember what percentage of that, you know, is allocated to those last few days when we're in orbit, which has a mean altitude similar to the ISS.

But kind of to underscore what Bryan was saying, we evaluate the attitude of the Shuttle every five minutes, you know, from when it first reaches orbit to when it de-orbits, and so that information is not available until a few weeks prior to the mission because we're always fine-tuning that, and by orienting the Shuttle in certain ways, we can absolutely reduce the risk. And that's why we have some general numbers early on, a few months before launch, and then we refine those numbers.

As we've done in the past on some Station missions, we actually went back and found better ways to orient the vehicle at different times during the mission solely to reduce the risk.

MEDIA QUESTIONER: Thank you.

MODERATOR: All right. Next is Frank Morring of Aviation Week.

MEDIA QUESTIONER: Thank you all for doing this.

Nick, I understand that you've been over to Europe a couple of times, I think since the collision, to talk about international efforts to mitigate the space debris problem. Have you seen a sense, a new sense of urgency since that collision, and could you sort of update us on the status of international efforts to mitigate and then perhaps even improve the situation?

Thank you.

MR. JOHNSON: Okay. Yeah. I was at the United Nations in Vienna about two weeks after the collision, and I wouldn't say there's an urgency. There was obviously an interest in the event and the consequences of it. It was a barometer for future situations in Low Earth Orbit or even high altitude.

But remember that, you know, I was at the Scientific and Technical Subcommittee of the COPUOS of the UN who has had space debris on the agenda since 1994. So they already have an interest. They are already very knowledgeable about space debris. So they do want to know about events which now have significantly altered and have changed for foreseeable future, for decades, the nature of debris in Low Earth Orbit where so many operational spacecraft are.

So, again, I don't think there is any urgency. There is continued discussion about getting greater compliance with the existing International Space Debris Mitigation Guidelines. There is obviously more interest in collision avoidance than there has been in the past, but I would say that it's been so soon after the collision, that that aspect of it is still sort of fluid, and no one is trying to jump to a solution yet because we're not quite sure what that is.

MEDIA QUESTIONER: If I could just follow, are there any changes in the works in the international regime to mitigate debris, to get a handle on this, this situation?

MR. JOHNSON: Well, we have been preaching -- and our international colleagues have been with us -- that the first order of business is not to create new debris unnecessarily, particularly long-lived debris, and so we are all on that same page. So we are all implementing through our various national mechanisms regulations where they are appropriate or guidelines for other countries and organizations, so that we can control the growth of the debris for those situations which we have control.

We can prevent accidental explosions. It is difficult to prevent accidental collisions.

MODERATOR: All right. Next is Stewart Powell from the Houston Chronicle.

MEDIA QUESTIONER: Good morning. Thanks for doing this.

Two quick questions. One is, is this the most dramatic maneuver that has been undertaken by Shuttle in the face of space debris, and how many miles will it move to avoid any further risk once it deploys the Hubble?

MR. JOHNSON: I think it is just a matter of timing because the orbiter has to come down, you know, before it does the final reentry burn anyway, and so the question was whether you leave it up at the Hubble altitude until the last day or you reduce the perigee, the lowest point, early on to reduce the overall risk.

So it really doesn't affect those last few days in space after Hubble has been serviced and redeployed.

MR. O'CONNOR: We would have to go back and find out if this is a precedent or the largest maneuver, and one of the things we may find when we look into that is that we have done other maneuvers for other reasons, like phasing to get a daylight landing and so on, which may have also been pretty big ones. But just for prevention of orbital debris, it could be, but we will have to go back and verify that for you.

MEDIA QUESTIONER: Thank you.

MODERATOR: Stewart, did you have a second question?

MEDIA QUESTIONER: I guess the second question is: What training do folks have to deal with a hit by catastrophic debris?

MR. O'CONNOR: There is extensive training for a generic loss of cabin pressure right up to and including an emergency de-orbit that the crew goes through, and sometimes, as a crewmember, you wonder why you train so much on such low-probability events. There is always the side benefit in such training of getting the crew to work a really tough emergency. The emergency itself may not be as important as the crew learning in working with each other and with the ground on any emergency that you get out of that. So we have traditionally treated that as one of our more important training sessions.

Now, they didn't necessarily tell us that it is due to orbital debris. That was kind of irrelevant. It could be a failure of a system or whatever, but that is what is closest for a Shuttle crew to training for a really bad orbital debris hit.

MEDIA QUESTIONER: Thank you.

MODERATOR: All right. Jeff Bliss of Bloomberg News.

MEDIA QUESTIONER: Yeah. Hi. I just wanted to ask you. You said earlier, Nick, that you weren't losing sleep over this right now, but you obviously are doing a lot of things to avoid collisions. I'm wondering, have you done any predictive models that look about when -- a time when you might have to lose sleep, where it gets so bad that it's going to be extremely scary?

And the other thing I wanted to find out, is there any efforts to try to -- is there any way of not necessarily limiting future debris but getting rid of the existing debris?

MR. JOHNSON: Well, actually, to be honest with you, I have lost sleep because I've been called many times at 1 o'clock or 2 o'clock or 3 o'clock in the morning.

MEDIA QUESTIONER: All right. Fair enough.

[Laughter.]

MEDIA QUESTIONER: But when there would be a time when you expect that this will be just a really big problem?

MR. JOHNSON: Yeah, yeah. It's, you know --

MR. O'CONNOR: But that was phone ringing, not your nerves, though, there.

MR. JOHNSON: That's right. That's right. That's the phone and not my nerves.

You know, we're talking decades, many, many decades. You know, the growth of the environment is continuous. As I said, it's still been relatively linear. Actually, in the late '80s and early '90s, we made some significant improvements, and the rate of growth of debris decreased. Unfortunately, with the Chinese ASAT test and this collision, it's bumped it back up, but if you take where we are today after those two events and go back to the early '60s, it's almost linear. So that's good news. It's not growing exponentially yet, but, you know, in the longer term, it will, and it's a classic environmental issue that it's easier to prevent a problem than to fix it.

And your last question actually had to do with remediation of the environment. That's a very, very difficult thing to try to undertake. We've been looking at it for many years. We are putting a little bit more effort into it, the least several years.

We have identified in 2006 that that was going to be a long-term challenge, is to remove the large resident space objects which are already there.

We're smarter now. We know how to -- for vehicles we're about to launch, we know how to make sure they come down quicker. We can't go up and affect those things which are already up there. So that, we don't know how to handle yet, but we are working the problem.

MODERATOR: All right. Tariq, Space.com.

MEDIA QUESTIONER: Hi. This is Tariq from Space.com and SpaceNews, and my question, Nick, is for you.

You mentioned, I guess, some mitigation options which you're looking at now, but is, I guess, for the foreseeable future, the next decade, the only thing that really seems viable is, I guess, collision avoidance?

And then I have a short follow-up. Thanks.

MR. JOHNSON: Well, I'm not quite sure I got the full question.

Collision avoidance, you know, is clearly something which is well within our means. We could evaluate the risk. We can take corrective measures if necessary, and we continue to look at better ways to protect the spacecraft before launch in terms of their design.

For robotic spacecraft, you are limited in where you can put shields because you have the payload that has to have its sensors available, and you have to have engines and other things basically exposed to the environment.

So it is a combination of operations and design and disposal. The disposal is one of the major issues, to make sure that we don't leave vehicles, be they spacecraft or launch vehicle stages, in places that are going to pose a threat for, you know, untold years.

MEDIA QUESTIONER: Thanks. That answers that question.

The follow-up is you kind of hinted at some future options for actual remediation. I think laser ablation was mentioned earlier. And I understand that it is a long-term problem, but could you kind of go over maybe a few of the most promising ways to remediate the environment, if it is sending people or robots up there to collect some of the largest or something like that?

Thanks.

MR. JOHNSON: I will divide this into two parts. There is removing small debris, you know, which does not normally involve, you know, individual, you know, rendezvous or attaching some sort of special mechanism, and the large debris which do.

So, if you were to rendezvous with an old spacecraft or rocket body and attach a drag augmentation device, so that it would fall back to Earth more quickly or you were to attach an electrodynamic tether, so that you could actually maneuver it into a lower orbit and eventual decay more quickly, I mean, those are certainly possibilities. Unfortunately, it's the cost of getting up there and attaching something to an uncooperative satellite that is probably tumbling.

For small debris, there are kind of catchers you can propose, you can think about. There are ideas with lasers, as we mentioned, I think, a little bit earlier, to try and perturb their orbits into ones which will fall back to Earth more quickly.

Again, there's a wide variety of different concepts which are applicable at different altitude regimes and applicable for different-size debris.

MODERATOR: Mark Mathews of the Orlando Sentinel.

MEDIA QUESTIONER: Thanks, guys. Quick question. Could you put into context the risk right now for the upcoming Hubble repair mission? From my reading, I mean, here we are, it's going to be at the highest altitude we have had and a steady increase of space debris over the years.

I guess from my end, it looks like this is going to be the riskiest Shuttle mission ever in terms of space debris. Is that right?

MR. O'CONNOR: This is Bryan O'Connor.

One of the things you have to remember is we are doing some things in recent history from our learning from Columbia that count as mitigations that we didn't used to do. We didn't used to look at the orbiter at the end of the mission to see if we had orbital debris strikes. So we didn't take account for that when we used to do our risk assessment. Now we do, and we do, do a late inspection on a vehicle. We look at it pretty closely. If we do see something that can be repaired, we will do that.

On Space Station missions and on this mission, a little different flavor to it, there is also a safe haven if we cannot de-orbit the vehicle. So, when we look at our loss of crew risk numbers, we account for safe haven and for a rescue mission.

Now, on this one, as you know, the safe haven is very short-lived. It is just some number of days. Rather than having a Space Station where you can safe-haven, you are going to have to safe-haven in the crippled vehicle itself, if it were to be crippled. So we've got two vehicles on the launch pad, so we can get a rescue mission up right away.

Those things are all mitigations that we never used to have. So I would hesitate to say the risk is higher. It is probably lower.

MEDIA QUESTIONER: Well, in terms of actually being struck by an object, is that higher? And then, I guess, are you also worried about increased risk to some of the astronauts themselves when they are out in space walks?

MR. O'CONNOR: Yeah. The risk caused by the environment is something that we can't really control. The orbit of the space -- or of the telescope is up in a higher risk region than Space Station is. So this is a riskier environment, let me put it that way, when we go up to this altitude. That's true.

MEDIA QUESTIONER: Would you say --

MODERATOR: Okay.

MEDIA QUESTIONER: -- it's the riskiest environment?

MODERATOR: We will come back. We will come back, Mark. And that is a reminder to everybody. Dial

Star/1 on your phone if you want to get in queue for a question. We are coming down to the end of our list. So we will start around the circuit again.

Next is Nell Greenfield Boyce of National Public Radio.

MEDIA QUESTIONER: Oh, hi. I want to talk about the risk of mission -- and maybe you addressed this earlier, I came a little late, I'm sorry -- to the Hubble Space Telescope itself. How has the environment around the telescope changed? Does that affect the risk of strikes or changes in its life span?

Also, you were talking about looking at the Shuttle for debris strike evidence. Does anyone have any sense of whether the Hubble is being sort of, you know, pummeled regularly and astronauts see that, and how do you monitor that?

Thank you.

MR. JOHNSON: Actually, Hubble is being pummeled regularly. During every servicing mission, we do extensive photographic surveys of the vehicle, and we see evidence of literally thousands of impacts not only from manmade debris but from the natural meteoroid environment.

You will recall we also brought back solar arrays from Hubble on previous missions, and we have examined those.

We are about to, during this mission, bring back a large external part of Hubble. We will be replacing it, and when we bring it back, we will look at its exposure over these many years and how many impacts we see per square inch, and that, again, will tell us something about the environment.

Yes, the environment has continued to grow with Hubble. The good news is that we have not yet determined that any of these impacts, most of which have been relatively small, have impeded at all the operation of the Space Telescope.

We did see, if you recall, on the very first servicing mission, a hole in one of the high-gain antennas, which was about three-quarters of an inch in diameter. Fortunately, even that hole did not affect the operation of the antenna. So we have been very fortunate, but, you know, every satellite up there is being hit by debris all the time. Fortunately, it's primarily small debris.

MODERATOR: All right. Jeff Brumfield of Nature

Magazine.

MEDIA QUESTIONER: Hello, there. Can you all hear me?

MODERATOR: Yes.

MEDIA QUESTIONER: Okay. So I was wondering. We have been talking a lot about Hubble, but I was wondering, Nick, if you had done some analysis of the satellites in higher orbits, closer to the debris zone from this collision in February, specifically the A-Train satellites and whether you saw any increased risk for those, those environmental monitoring satellites.

MR. JOHNSON: The answer is yes, we have, and yes, the risk has increased. We see that clearly from the large debris population which is being tracked by U.S. Space Command or U.S. Strategic Command. They have already cataloged over 900 new debris.

Now, not all those go through the A-Train altitude. Actually, less than half of them do, but, you know, there is an additional risk. We are seeing additional conjunctions for those satellites, and we have gone one step further. We have already collected data with the Haystack Auxiliary and the JPL Goldstone Radars. So we have a better indication of how many small particles were produced during this collision.

It turns out that there were more large particles from the Cosmos satellite, but there appear to be more smaller particles from the Iridium satellite, and so that now allows us to specifically look at the elevated risk to any of the satellites in the A-Train.

MEDIA QUESTIONER: Can you give a rough estimate of how the risk has changed in numbers and also whether you are planning any collision avoidance maneuvers for those satellites?

MR. JOHNSON: You know, we only plan collision avoidance maneuvers a couple days beforehand because that's the nature of the game. You can't predict much more than a few days into the future.

So, as Strategic Command advises us of potential close approaches, then we will evaluate that and then go into our mode of making a decision on whether or not a collision avoidance maneuver is necessary and implementing it, if that be the case.

We don't normally look at what is the increased risk from the small untracked debris because that is something we just have to live with, and knowledge of that number really doesn't make you any safer.

MEDIA QUESTIONER: Thank you.

MODERATOR: James Dean, Florida Today.

MEDIA QUESTIONER: Hi. I just was wondering if you could discuss that satellite collision a little further. I still don't quite understand why -- I am not quite clear if it was seen coming but nothing could be done about it or if, in fact, even though we are tracking objects that large and really know where they are, there's still times when we can't -- if we can't see that kind of a collision coming, how confident we can be in the very small objects or just how confident generally we are in our ability to track objects of all sizes, even though we do the best we can.

MR. JOHNSON: Well, it is up to the owner-operator of the vehicle to decide whether or not he wants to go through the effort to have conjunction assessments performed and then be prepared to do a collision avoidance maneuver if necessary, as I said, and NASA would do that for all of our maneuverable spacecraft, but the U.S. Space Surveillance Network does not have a mission to warn every commercial or foreign operator that something might be coming close by their satellites.

There are hundreds of operational satellites, and most of them work in environments even worse than the A-Train environment. You know, flying up around 800, 850 kilometers is the worst region right now, and so it is up to individual operators to decide whether or not they want that knowledge and are prepared to respond if warned.

MEDIA QUESTIONER: Well, if that is likely to be a cause of creating more debris, though, would we benefit from -- I don't know how feasible it is, but from trying to implement some broader warning system to avoid collisions like that?

MR. JOHNSON: Actually, the Department of Defense has already increased their conjunction assessment process for a larger number of operators. So they are working that problem, but it is part of an overall risk management approach. Because there is still uncertainty involved in these calculations, some operators, unless the quality of the data improves dramatically, may elect simply to ignore the information. So it is actually a very complex situation.

MODERATOR: All right. We will go to Seth Borenstein now, Associated Press.

MEDIA QUESTIONER: Thanks again for doing this.

Nick, just in terms of you talked about how you had the five maneuvering in 2008. Is there a year-by-year count? In other words, are avoidance issues going up more, avoidance maneuvers going up? I know you said that things are on the downside until -- you know, you had slowed the increase in debris until, of course, the Chinese ASAT. Do you have year-by-year figures to show if there is any trend in terms of the need to maneuver a way?

And then another question is I just want to make sure that on that page 5 of whatever it is that shows the chart, that is pre-collision. Right?

MR. JOHNSON: The answer to your last question, yes. This chart, the red line was January of 2009. So it was a month before. So that second peak there just under 800 kilometers is clearly higher now, as are the surrounding areas, and as soon as the identification process has sort of leveled off, which it has not yet, we will be updating that chart, but the U.S. Strategic Command is still adding debris to its catalog on a weekly basis, and so we are going to wait before we try to update this

And now I've lost track of your original --

MEDIA QUESTIONER: A year-by-year trend of the collision avoidance.

MR. JOHNSON: Yeah. Actually, in the early phase of the ISS program, we were doing collision avoidance more frequently than once a year, but we improved the process. The environment really didn't change that much, but we improved the process, so there were fewer false alarms. So we went for several years without any maneuver at all until the first maneuver last August, and actually, that was due to fragmentation from a Russian vehicle which had fragmented above it early last year, and so it was sort of a unique situation. And we did have a significant increase in false -- in warnings, alerts of debris from that particular Russian fragmentation.

With our EOS satellites at 705 kilometers, we absolutely see an increase of 10 or more percent following the Chinese ASAT, which if you recall occurred at 850 kilometers, again, 150 kilometers above the A-Train, but there's enough debris down there that we definitely see a larger number of conjunctions.

So, again, it is very altitude-dependent on how the environment has changed.

MEDIA QUESTIONER: So what about at the 620 altitude then?

MODERATOR: Seth? Seth, we'll come back.

Tariq Malik, you're on again.

MEDIA QUESTIONER: Thank you very much.

Nick, you mentioned earlier, I guess there were measures that you took before the Chinese ASAT test to reduce the amount. I was wondering if you could kind of go over briefly what those were.

And then, also, if the current linear trend progresses, I am just wondering if there are any orbits you foresee as becoming untenable in the next decade or so for future satellites.

Thanks.

MR. JOHNSON: Again, at risk of forgetting the first question, let me answer the second question first.

No, within the next 10, 20 years, I can't even imagine that any region of space would be, quote, "untenable," unquote, you know, notwithstanding, you know, unforeseen events occurring.

The rate of growth is not that great. The risks, again, are very, very low. I mean, we've had one serious accident in 50 years. That has not changed overnight. So we may see increased risk, but it will be modest increases.

And now you're going to have to remind me again what was the first part of the question.

MEDIA QUESTIONER: Sure. Thank you for that. The first question was just if you could kind of briefly go over the measures that you had mentioned prior to the ASAT test that, I guess, had that reduction in debris.

MR. JOHNSON: It has to do with technical accuracy of the conjunction assessment data from the JSpOC, where we're doing a better job of predicting atmospheric density, which affects the trajectories and, therefore, of course, the potential for collisions.

It is partly in doing numerical calculations as opposed to analytical calculations. You could get higher accuracies, and so that has allowed us to shrink the so-called "keep-out regions" around the vehicles because if before we had this large 4-kilometer-by-4-kilometer-by-10-kilometer ellipsoid we put around the Shuttle and said if anything came within it, you know, we were concerned and may had to consider a maneuver, well, that now is what we call a "pizza box," which is much, much reduced in volume, and that has reduced the alarms and our need to go evaluate these conjunctions.

MODERATOR: All right. Bill Harwood, you're next.

MEDIA QUESTIONER: Thanks.

Nick, I will challenge you with two questions myself. How long will it be before the ASAT debris and the more recent collision debris filters down to the Station altitude? In other words, will the risks go up for future Station Shuttle flights as that debris decays? That is part one, and then I had a follow-up.

MR. JOHNSON: Okay. The answer is already there. I mean, right immediately after both of those events, there were debris that were thrown down into Space Station altitudes. However, the good news is that that debris is relatively short-lived because the atmospheric density is so much greater there. So that actually washed out very quickly.

So now we are in a mode of where debris is slowly decaying from higher altitudes down to where the Station is. So what happened immediately after each one of those events, there was a temporary increase in risk, and then that tapered off substantially over the ensuing few weeks, and now we're at a new steady state, if you will, which is just marginally higher risk than before, because remember there is always a pretty substantial background there, and so we are not noticeably increasing that risk.

So, yeah, it's more than it was, but it's a relatively small percent.

MEDIA QUESTIONER: Thanks. And my only other question is really kind of a perception or philosophical question. I mean, it almost sounds like what you're telling us is, as reporters, we always want to write about the sky is falling or whatever, but it sounds like you're saying this really isn't a major story right now. You're saying that space debris, while it's a concern, it's a low order of concern, at least that's the way I'm interpreting what you're saying, and it's not something our editors and us should be all that -- "upset" is not the right word, but it's not something that should be hyped up.

I'm just trying to get a sense of -- again, my first question was what is the real risk, and it sounds like you're saying it's not that high. Am I misinterpreting this?

MR. JOHNSON: No. In general, I agree with how you characterize that. You know, it's a serious -- was risk. You know, we spend a lot of time and effort trying to prevent new debris, on, you know, protecting our vehicles either with shields or with collision avoidance maneuvers. So, yeah, we do take it very, very seriously, but in the scheme of things, it's a small risk.

For most robotic spacecraft, risk of failure from other sources, from solar event, flares, or other reliability issues associated with the parts of a vehicle are much higher than the risk of being hit by orbital debris that might terminate the mission.

So it's a serious issue. It's not the most important issue that we have for many of our vehicles. We're aware of it. We're doing everything we possibly can. We're improving our capabilities to protect the spacecraft on a yearly basis, and we have the international community on board. So other people are doing the same thing. This is a big environment. The U.S. doing something all by itself, you know, is not sufficient. We have to have everybody working with us.

So the answer to your other -- or to respond to your other comment is, yeah, we don't think this is a page-one story. You know, there is no, you know, serious new issue that we have not been aware of and needed to be addressed. This is just, you know, part of what we've been working with for many, many years.

MODERATOR: All right. Mark Mathews, your turn again.

MEDIA QUESTIONER: Thanks, guys.

One, I have a brief background question. What is the average risk for a Shuttle mission to the International Space Station? Is it 1 in 300? And then I wanted to see also, have you guys calculated the risk for the EVAs during the Hubble mission of actually not being hit by space debris then?

Thanks.

MR. O'CONNOR: Yeah. The Station missions are coming out in the 300s, and so that shows you the difference between what we have for this mission and those.

And we always do calculate any special risks like, for example, when we do EVA to make sure that there is no risk level for EVA that doesn't meet our threshold. Again, our threshold for decision at the program level is 1 in 200, and what that means is if you get to a worst risk than that, then you have to do something different. You have to knock off the EVA early or you'd have to change the attitude of the orbiter to protect the EVA crewmembers.

Shadowing is one of the mitigations that we use for EVA. I don't remember the risk numbers for EVA for this mission. We did review those as a routine part of our overall risk assessment for the mission, but the risks were well below the threshold for taking further action.

MODERATOR: All right. Rob Coppinger, Flight International.

MEDIA QUESTIONER: Hello, again. Yes. I'd like to have a bit more detail on that laser ablation, that continuing laser ablation assessment work.

MR. JOHNSON: As I said, in 1996, NASA and DoD released a study called Project Orion, which envisioned maybe having a ground-based laser irradiate small debris at, you know, modest altitudes, and the idea would be to perturb the orbit of the debris either by momentum exchange and/or the reaction of ablation of the material after it was irradiated by the laser.

The concept there was to change the orbit such that it would become a little bit more eccentric, so it would have a lower perigee, and then the object would fall back to Earth more quickly.

Part of the problem there is before you can irradiate it, you have to be able to track it first. You have to discover it. So the laser had to be co-located with some other detection radar that could see down to very small particles, typically below, you know, 5 or 10 centimeters. So it turned out to be a relatively involved process.

And then the other issue is the debris are not simple spheres where you can predict what is going to happen when you irradiate them. These are all -- kind of think about Corn Flakes. They're weird shapes, a variety of materials. They are tumbling. So, once you are irradiating it, it is still tumbling even during that process, and so the exact effect it would have on the orbital pertubation can vary, and so you need to make sure that you're not going to make the matters worse and not bring it down into a low orbit.

MEDIA QUESTIONER: Did I misunderstand you before? I got the impression you said you were still assessing this and the work going on.

MR. JOHNSON: We understand the basic concept. Actually, I have reviewed it again recently in the past year, but the basic technical and economic challenges still exist.

You know, firing a laser, a high-powered laser on particles of which we have, for example, 300,000 in Low Earth Orbit, that is quite an operation to be able to remove a significant portion thereof.

MODERATOR: All right. Alexis from Wired.

MEDIA QUESTIONER: Hey, guys. Thanks for doing this again. I appreciate it too.

I am wondering what would have happened if you hadn't been able to get the risk lower than the 1-in-200 threshold. Like has that happened before where you have had to go to higher approval, maybe one of the earlier missions, before you added the late inspection?

MR. O'CONNOR: No, I don't think we've had a case -- in my memory, we have not had a case where MMOD risk after all mitigations remained significantly below that threshold. There may have been one that was very close. I can't -- I can't remember, but if we were significantly below that threshold and we had done everything we could, then the question would be are we -- can we reduce the length of the mission and still accomplish the minimum mission success criteria.

Each of our missions has such criteria. We call it "minimum mission success," and that would become a trade item right there.

Now, the program manager may want to defer that to higher authority because the program manager is responsible for executing the entire mission, full mission success. So it would probably be up to the Associate Administrator level, be a Headquarters discussion, and that is why we have that threshold is to allow a discussion at a higher level.

Now, what more mitigation could be done, presumably you wouldn't go to Headquarters until you have done everything you can in your power at that level, operational and so on. So then the idea would be relieve the program of accomplishing part of the mission or maybe accepting that risk level in view of spreading the risk over a larger time. There may be other missions where you are way below that risk threshold, and over a period of time, you might be able to justify a single mission that doesn't meet it, but those would be discussions you would have to have. We haven't done that sort of thing, but it does, I hope, answer what could be done if you reach that level.

MEDIA QUESTIONER: Sure. Thank you.

MODERATOR: All right. One last question. Seth, you are batting clean-up.

MEDIA QUESTIONER: Okay, great. Thanks.

Just for at the 600-kilometer altitude where Hubble is and where the mission mostly is going to be, is there a way of characterizing how much additional space junk or the density increased first with ASAT and then with the collision? I mean, we could see it sort of ASAT, but to characterize the change in there, and is there any satellite that can move that you've had to move at that altitude? I know you can't move Hubble.

MR. JOHNSON: The answer to the first part of your question, yeah, we have done that explicitly. We have evaluated the risk to STS-125 solely based on the debris that was produced during the collision. We have also identified the incremental increase in risk from the residual Chinese ASAT debris. Yeah, that all goes into the environment going into the model, and it comes out as a specific factor. So we do know that. I can't tell you those numbers, you know, necessarily off the top of my head.

MEDIA QUESTIONER: Were they big or anything?

MR. JOHNSON: Well, again, you know, once you roll them all up with the background environment and all the other things up there, it still came out to this 1 in 221.

MODERATOR: All right, everyone. Thanks for being on today. Let me give you a little bit of information about how you can obtain a replay of this telecon.

There are two ways. Sometime after 5:00 p.m., Eastern Time, today, possibly as late as tomorrow morning, it will be absolutely at nasa.gov/newsaudio, along with a transcript, and you can also for the next two weeks until midnight, May 12, obtain it through the conferencing coordinator. The toll-free number to call to hear a replay is 866-451-8896. If toll free doesn't work for you, the toll number is 203-369-1202, and your passcode for that is 4280.

And we do plan to have a video file with Nicholas Johnson featured for our TV friends at 5 o'clock this afternoon.

With that, we will call it a briefing and thank everyone for being online, and please do remember to honor that 5:00 p.m., Eastern Time, embargo.

Thank you.

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